

Description

SYSTEM FOR PREVENTING SWING WAG FOR A WORK MACHINE
WITH A BOOM ASSEMBLY

Technical Field

- [01] This invention relates to the field of work machine swingable booms, and, more particularly, to a system for preventing swing wags.

Background

- [02] Work machine boom assemblies serve a variety of functions such as, digging ditches, loading work trucks, and laying pipe. In order to carry out these functions, the boom assembly must be capable of swinging from side-to-side by rotating the boom about a pivotal connection to the frame. A pair of hydraulic cylinders having one end connected to the boom assembly and the other end connected to the frame of the work machine aide in rotating the boom assembly by extending one cylinder while the other retracts.
- [03] When an operator swings the boom assembly quickly and the stop command is given, the swing valve closes and the boom assembly rapidly decelerates. As the boom assembly approaches zero angular velocity, the remaining energy in the swing system is in the form of potential energy stored in the oil and kinetic energy in the swinging boom assembly. The kinetic energy in the swinging boom assembly bounces off the potential energy in the oil and spikes the pressure in the swing system. The pressure spike is enough to blow the relief valve and let oil escape the swing system. Cavitation occurs from the oil-starved swing system, resulting in the boom assembly bouncing from side to side until the energy is dissipated. This is known in the industry as "swing wag" and is undesirable due to pressure spikes in the system, resulting in damage to the hydraulic system and leading to pre-mature life or failure.

[04] Typically, a charge valve or similar device may be used to control “swing wag”. One known “swing wag” control apparatus is found in U.S. Patent 4,757,685, issued to Jerry J. Burckhartzmeyer on July 19, 1988.

Burckhartzmeyer discloses a hydraulic control circuit, which utilizes the pressurized fluid from the main supply conduit upstream of the directional control valve to super charge the makeup valves when the directional control valve is in the neutral position. By supercharging the makeup valves, any fluid lost from the associated circuit is immediately replenished, thereby avoiding or minimizing the creation of voids in the system.

[05] The present invention is directed to overcoming one or more of the problems set forth above.

Summary of the Invention

[06] In an embodiment of the present invention, a swing cushion system of a work machine includes a directional flow device having a directional control member, a control device coupled to the directional flow device that outputs a signal to the directional flow device to shift the directional control member to dissipate energy in the fluid.

[07] A method for dissipating fluid energy in a swing cushion system of a work machine is also disclosed. The system includes a directional flow device having a directional control member and a control device coupled to the directional flow device. The method includes the steps of producing a stop swing command, generating a signal indicative of variable pre-determined parameters, and dissipating energy in the swing cushion system in response to the signal.

Brief Description of the Drawings

[08] Fig. 1 is a drawing of a representative work machine embodying the present invention;

- [09] Fig. 2 is a partial diagrammatic and partial schematic of an embodiment of a swing cushion system; and
- [10] Fig. 3 is a flowchart of an algorithm for controlling the swing cushion system.

Detailed Description

- [11] Fig. 1 depicts a work machine 100, illustrated in the embodiment shown as a vehicle 102 having a swingable boom assembly 104, such as a backhoe. The features as disclosed herein finds application with any work machine having a swingable boom or boom assemblies, including, but not limited to, single boom assemblies, multiple boom assemblies, forestry boom assemblies, and dredging boom assemblies. The boom assembly 104 is shown includes a boom 101, a stick 103 attached to the boom 101, and a bucket 105 attached to the stick 103. The boom assembly 104 is pivotably connected to a boom support bracket 106 by means known in the art. The boom support bracket 106 has upper and lower pivotal portions 108,110, pivotably connected to upper and lower mounting frames 112,114, respectively, of the work machine 100, which allows the boom assembly 104 to rotate about a vertical axis within a pre-determined range. A plurality of motors 116, in the embodiment shown as hydraulic cylinders, are located on opposing sides of the boom support bracket 110 and pivotably connected to the boom support bracket 110 and the lower frame 108.
- [12] Fig.2 is a partial diagrammatic and partial schematic of a swing cushion system 200 of the work machine 100. The swing cushion system 200 includes a source of pressurized fluid 202, which in the embodiment shown is a pressure compensated variable displacement pump, but is not limited to a fixed displacement pump, or the like. Coupled to the source of pressurized fluid 202 is a reservoir of fluid 203. The swing cushion system 200 may also include a pressure relief valve 204 for relieving excess pressure in a known manner.
- [13] A fluid flow-control apparatus 206 coupled to the source of pressurized fluid 202 includes a directional flow device 208, and a flow

compensation device 210. The directional flow device 208 includes a directional control member 212, known in the art as a spool, slidably positioned within the directional flow device 208. The directional control member 212 has radial grooves 214 with pre-determined widths and depths. The radial grooves 214 are spaced at pre-determined locations along the axial length of the directional control member 212. The directional flow device 208 is open when the directional control member 212 shifts from its closed position and the radial grooves 214 are positioned to allow fluid to flow through at least one passage 216 of the directional flow device 208. The source of pressurized fluid 202 is pressure compensated by fluid pressure inputted from the fluid flow-control apparatus 206 to vary the output fluid flow of the source of pressurized fluid 202.

[14] As illustrated in the embodiment, the plurality of motors 116 is coupled to the fluid flow-control apparatus 206. A control device 218, such as a programmable electronic control module (ECM), is coupled to the directional flow device 208 and is capable of receiving a signal, and outputting a signal indicative of a plurality of pre-determined parameters, such as, but not limited to a sinusoid signal with time, magnitude, or frequency parameters. An operator input device 220 is coupled to the control device 218 and is capable of outputting a signal indicative of an operator command to the control device 218. In one embodiment the signal is a swing command signal X_c , but is not limited to raise and lower boom commands, extend and retract stick commands, or work tool commands.

[15] Fig. 3 is a flowchart of an algorithm 300 of the swing cushion system 200 for controlling "swing wag". The algorithm 300 starts at block 302 and upon receiving the swing command signal X_c from the operator input device 220, control passes to block 304 and block 306. Block 304 sends a signal to block 308 indicative of the directional flow device 208 being closed or open. For example, if the directional control device 208 were open, the signal sent to block

308 would be +1, inversely, if the directional flow device 208 were closed, the signal sent to block 308 would be -1.

[16] Block 306 outputs a signal to block 310 indicative of the change rate variable of the swing command signal X_c with respect to time. For example, the change rate variable equation of the swing command signal X_c would be $((X_{cmax} - X_{cmin}) / \Delta t)$. Block 310 converts the change rate variable into a constant using a pre-determined conversion factor, if the change rate variable is within a pre-determined range. For example, if change rate variable provided from block 306 were within the pre-determined range, the conversion factor would be applied to provide a constant within a pre-determined range of, for exemplary purposes the pre-determined range is 1-10. If the change rate exceeds the pre-determined range, a constant indicative of such would be provided. For example, a change rate exceeding the pre-determined range provides a constant of 0. Block 310 then sends a signal to block five indicative of the constant provided by block 310.

[17] Block 308 then determines if a signal indicative of pre-determined parameters should be sent to the directional flow device 208 to move the directional control member 212. Upon determination that a signal is needed block 308 sends a control signal to block 312 to generate and send a signal, for example a sinusoid signal, to the directional flow device 208. The sinusoid signal comprises a time parameter, a magnitude parameter, and a frequency parameter. For example, if block 308 received a signal from block 304 of a constant +1, meaning the fluid directional flow device 208 is closed, and the signal from block 310 was a constant between 1-10, meaning the change rate was within a pre-determined range, then block 312 would send the sinusoid signal to the directional flow device 208 representative of the change rate constant.

Industrial Applicability

[18] Upon a swing command signal X_c from the operator, the control device 218 sends a signal to the directional flow device 208, shifting the

directional control member 212 to allow fluid to flow through the passages 216. The source of pressurized fluid 202 provides pressurized fluid to the plurality of motors 116 attached to the boom support bracket 106, to which the boom assembly 104 is attached. The plurality of motors 116 extends and retracts respectively to swing the boom assembly 104, within the pre-determined range, until the operator gives a stop swing command signal X_c and the boom assembly 104 comes to a stop.

[19] In order to perform the aforementioned function, the swing command signal X_c is sent from the operator input device 220 to the control device 218 representative of a stop swing command signal X_c . The control device 218 sends a signal to the directional flow device 208 to shift the directional control member 212, to a closed position, to stop fluid flow. The boom assembly 104 decelerates rapidly, and as the boom assembly 104 approaches zero, all the remaining energy in the swing cushion system 200 is in the form of potential energy in the fluid. The algorithm 300 is used to dissipate the energy in the swing cushion system 200, to bring the boom assembly to a stop without "swing wag".

[20] The control device 218 receives the stop swing command signal X_c from the operator input device 220 and is inputted into the algorithm 300. The algorithm 300 checks the directional flow device 208 for either being open or closed, and also calculates the change rate of X_c with respect to time. Upon the change rate not exceeding a pre-determined range a conversion factor is applied to the change rate. The change rate is converted to a constant within a pre-determined range. Upon the fluid directional flow device 208 being closed and the constant within a pre-determined range, the control device 218 sends the sinusoid signal representative of the constant to the directional flow device 208. The sinusoid signal having pre-determined parameters of time, amplitude, and frequency oscillate the directional control member 212, dissipating the energy in the swing cushion system. For example, a constant of 5 would send the sinusoid

signal of 0.5s, 30% of full amplitude, and at 10Hz. This would move the directional control member 212 at 10 Hz for 0.5s at 30% of full amplitude.